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- (54) **MIM CAPACITOR STRUCTURE**
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(58) **Field of Classification Search**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

5,541,428	A *	7/1996	Nagatomo	257/306
5,903,023	A *	5/1999	Hoshi	257/300
5,977,582	A *	11/1999	Fleming et al.	257/310
6,046,467	A *	4/2000	Arita et al.	257/295
6,115,233	A *	9/2000	Seliskar et al.	361/303
6,227,211	B1 *	5/2001	Yang et al.	134/1.1
6,281,134	B1 *	8/2001	Yeh et al.	438/706
6,720,232	B1 *	4/2004	Tu et al.	438/396
6,919,244	B1 *	7/2005	Rommel et al.	438/239
7,956,400	B2	6/2011	Smith	

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 14/289,739 Filed on May 29, 2014.

(Continued)

Primary Examiner — Matthew Landau

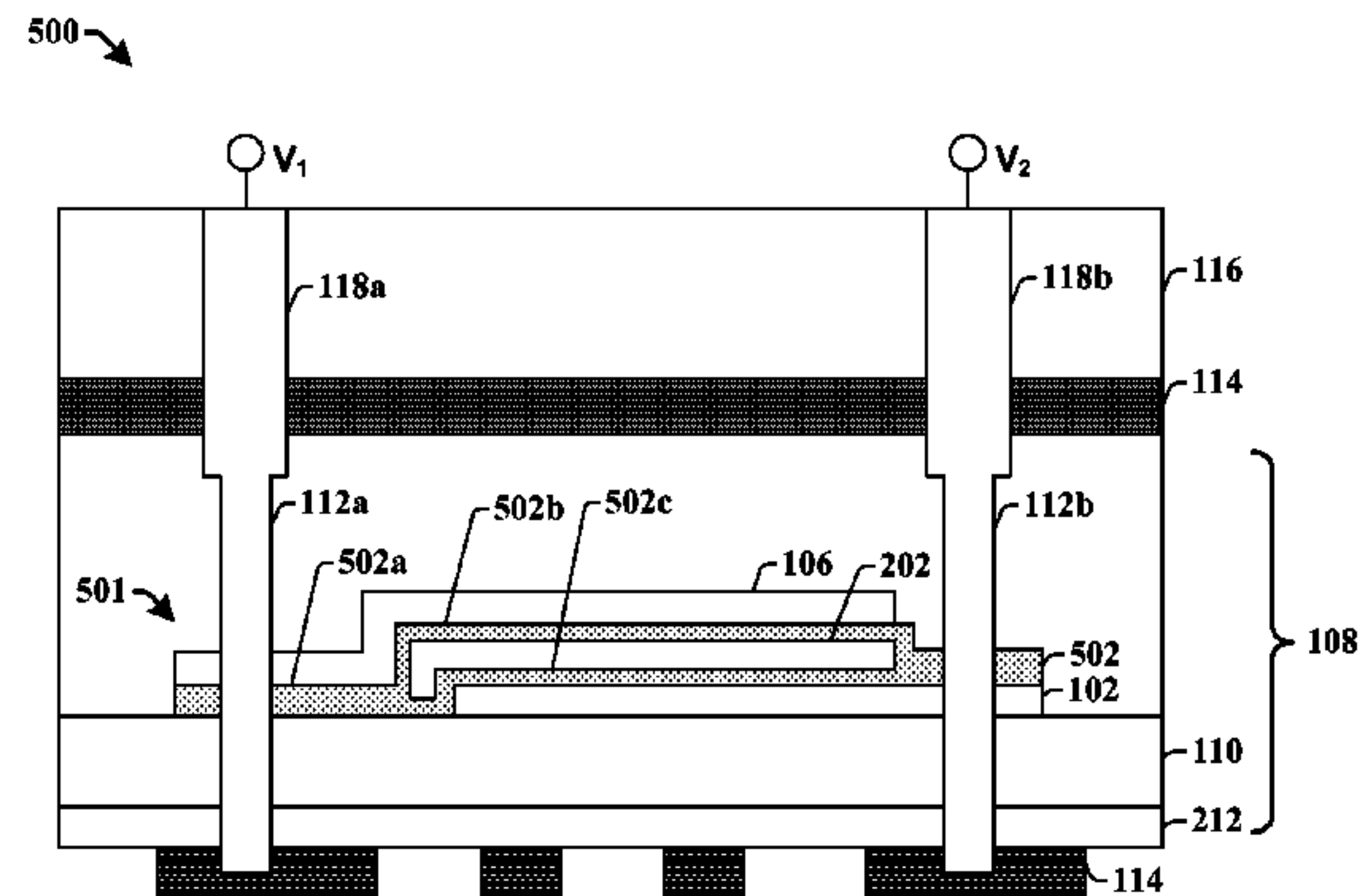
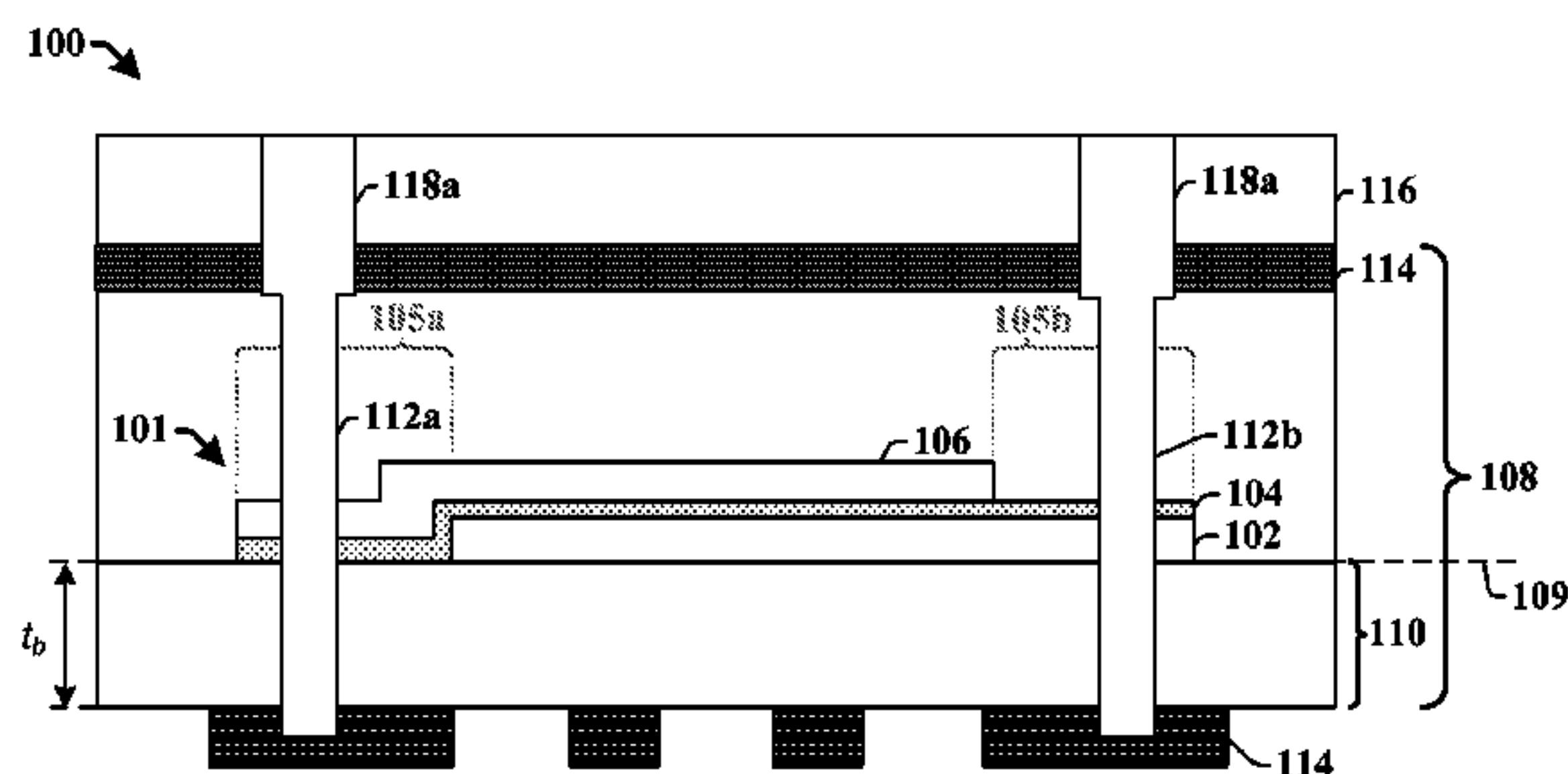
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(57) **ABSTRACT**

The present disclosure relates to an integrated chip having a MIM (metal-insulator-metal) capacitor and an associated method of formation. In some embodiments, the integrated chip has a MIM capacitor disposed within a capacitor inter-level dielectric (ILD) layer. An under-metal layer is disposed below the capacitor ILD layer and includes one or more metal structures located under the MIM capacitor. A plurality of vias vertically extend through the capacitor ILD layer and the MIM capacitor. The plurality of vias provide for an electrical connection to the MIM capacitor and to the under-metal layer. By using the plurality of vias to provide for vertical connections to the MIM capacitor and to the under-metal layer, the integrated chip does not use vias that are specifically designated for the MIM capacitor, thereby decreasing the complexity of the integrated chip fabrication.

20 Claims, 4 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

8,298,875 B1 10/2012 Or-Bach et al.
 8,546,914 B2 10/2013 Su et al.
 8,753,953 B1* 6/2014 Cheng et al. 438/396
 2001/0046737 A1* 11/2001 Ahn et al. 438/253
 2002/0094656 A1* 7/2002 Armacost et al. 438/396
 2003/0049885 A1* 3/2003 Iijima et al. 438/106
 2003/0178665 A1* 9/2003 Takenaka 257/306
 2003/0178666 A1* 9/2003 Lee et al. 257/306
 2003/0232481 A1 12/2003 Huang et al.
 2004/0061177 A1* 4/2004 Merchant et al. 257/349
 2004/0140527 A1* 7/2004 Furuya et al. 257/532
 2004/0180530 A1 9/2004 Li et al.
 2004/0256654 A1 12/2004 Korner et al.
 2005/0062130 A1* 3/2005 Ciancio et al. 257/532
 2005/0170583 A1* 8/2005 Park 438/253
 2005/0205913 A1* 9/2005 Yaegashi 257/296
 2006/0145293 A1* 7/2006 Cho 257/532
 2007/0045702 A1 3/2007 Liang
 2007/0200162 A1* 8/2007 Tu et al. 257/314
 2008/0055816 A1* 3/2008 Park et al. 361/301.4
 2008/0061345 A1* 3/2008 Wang 257/306
 2008/0217775 A1* 9/2008 Pai et al. 257/751
 2008/0277762 A1 11/2008 Takewaki
 2008/0290459 A1* 11/2008 Barth et al. 257/532
 2009/0008743 A1 1/2009 Lee et al.
 2009/0014835 A1* 1/2009 Furumiya et al. 257/535
 2009/0134493 A1 5/2009 Iwaki
 2009/0200638 A1* 8/2009 Smith 257/532
 2010/0065944 A1* 3/2010 Tu et al. 257/532
 2010/0079929 A1* 4/2010 Smeys et al. 361/524
 2010/0127350 A1* 5/2010 Totsuka 257/532
 2010/0164669 A1* 7/2010 Soendker et al. 336/200
 2010/0213572 A1* 8/2010 Ching et al. 257/532
 2010/0270643 A1* 10/2010 Iwaki 257/532
 2010/0289108 A1* 11/2010 Meinel et al. 257/467
 2010/0301451 A1* 12/2010 Iwaki 257/532
 2011/0303284 A1 12/2011 Kim et al.

2012/0091559 A1* 4/2012 Tu et al. 257/532
 2012/0181657 A1* 7/2012 Wu et al. 257/532
 2012/0199946 A1* 8/2012 Kageyama 257/532
 2012/0319239 A1* 12/2012 Chang et al. 257/532
 2013/0020678 A1* 1/2013 Tu et al. 257/532
 2013/0193556 A1* 8/2013 Lee et al. 257/532
 2013/0270675 A1* 10/2013 Childs et al. 257/532
 2013/0277680 A1 10/2013 Green et al.
 2013/0285203 A1* 10/2013 Hiroi et al. 257/532
 2013/0292794 A1* 11/2013 Pai et al. 257/532
 2013/0300003 A1* 11/2013 Sun et al. 257/788
 2013/0320493 A1* 12/2013 Chang et al. 257/532
 2014/0159200 A1* 6/2014 Loke et al. 257/532
 2014/0291805 A1* 10/2014 Hong 257/532
 2015/0028408 A1* 1/2015 Meiser et al. 257/302
 2015/0048483 A1* 2/2015 Kuo et al. 257/532
 2015/0061073 A1 3/2015 Kim et al.
 2015/0108605 A1* 4/2015 Park et al. 257/532
 2015/0115408 A1* 4/2015 Sun et al. 257/532

OTHER PUBLICATIONS

U.S. Appl. No. 14/249,482 filed on Apr. 10, 2014.
 U.S. Appl. No. 14/249,498 filed on Apr. 10, 2014.
 Non Final Office Action Dated Jul. 14, 2015 U.S. Appl. No. 14/289,739.
 Notice of Allowance dated Aug. 14, 2015 for U.S. Appl. No. 14/249,482.
 Non-Final Office Action dated Aug. 14, 2015 for U.S. Appl. No. 14/249,498.
 Final Office Action Dated Dec. 14, 2015 U.S. Appl. No. 14/249,498.
 Final Office Action Dated Dec. 31, 2015 for U.S. Appl. No. 14/289,739.
 Notice of Allowance dated Feb. 12, 2016 for U.S. Appl. No. 14/249,498.
 Notice of Allowance Dated Apr. 22, 2016 U.S. Appl. No. 14/289,739.

* cited by examiner

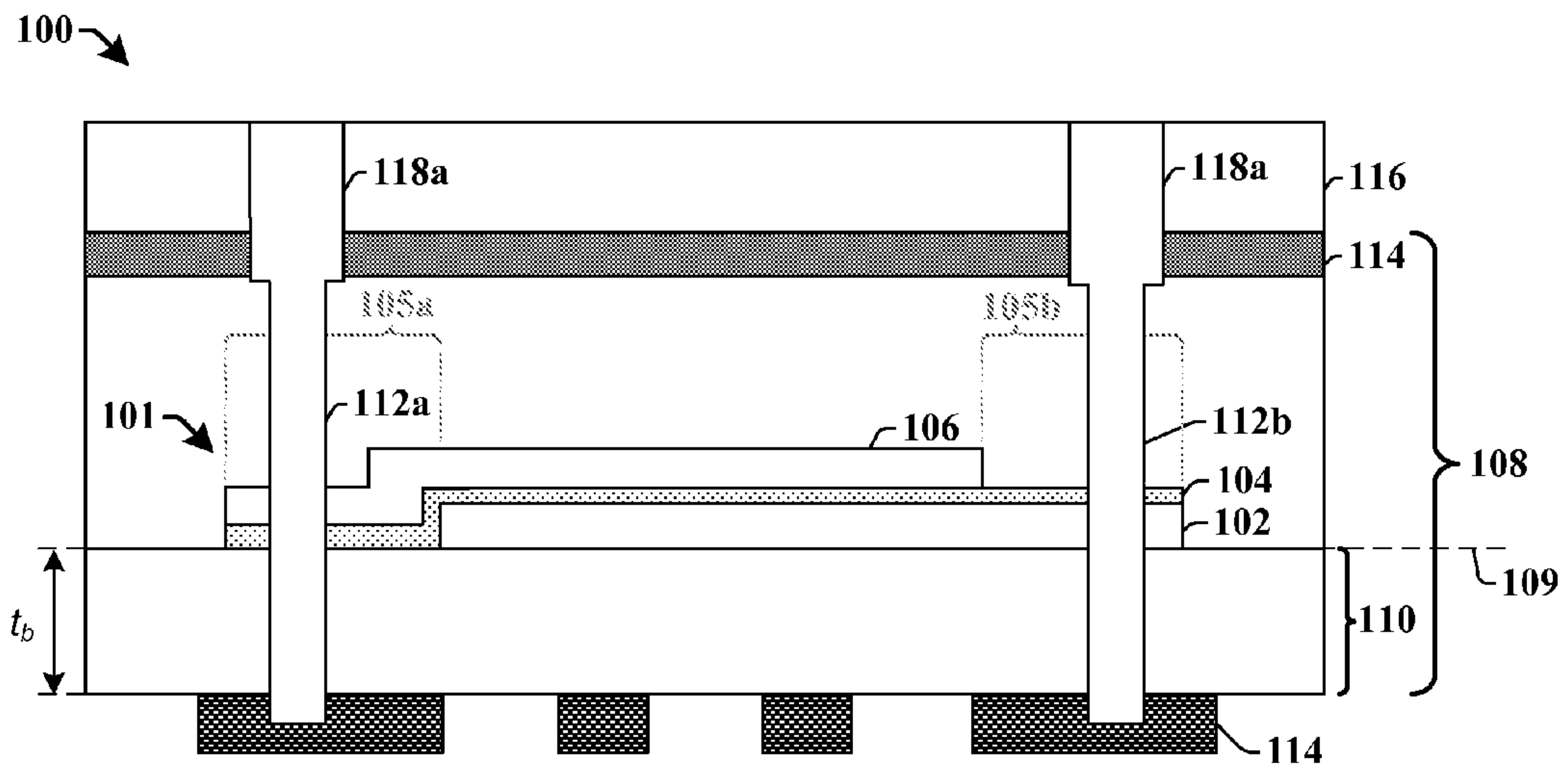


Fig. 1

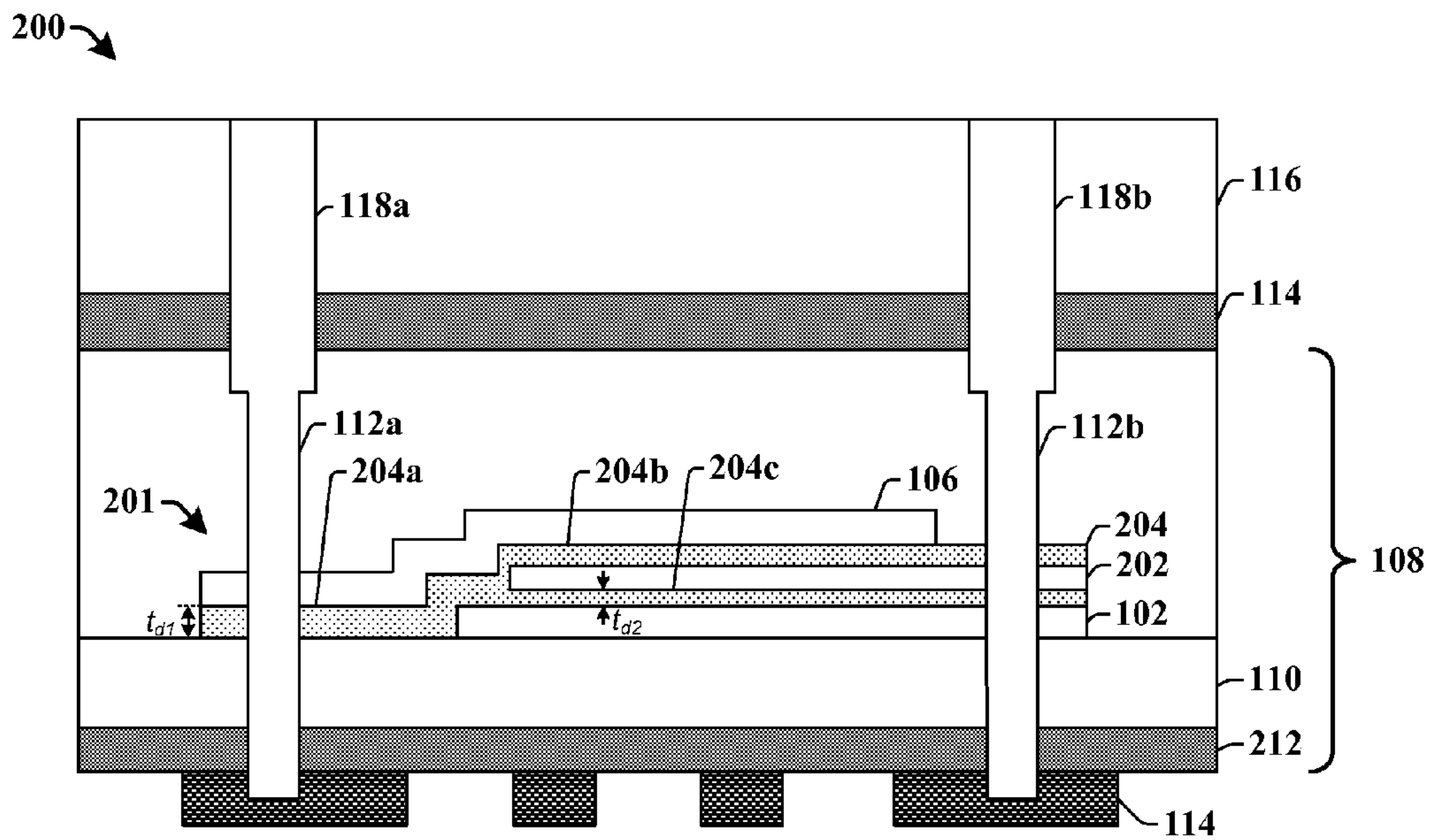


Fig. 2

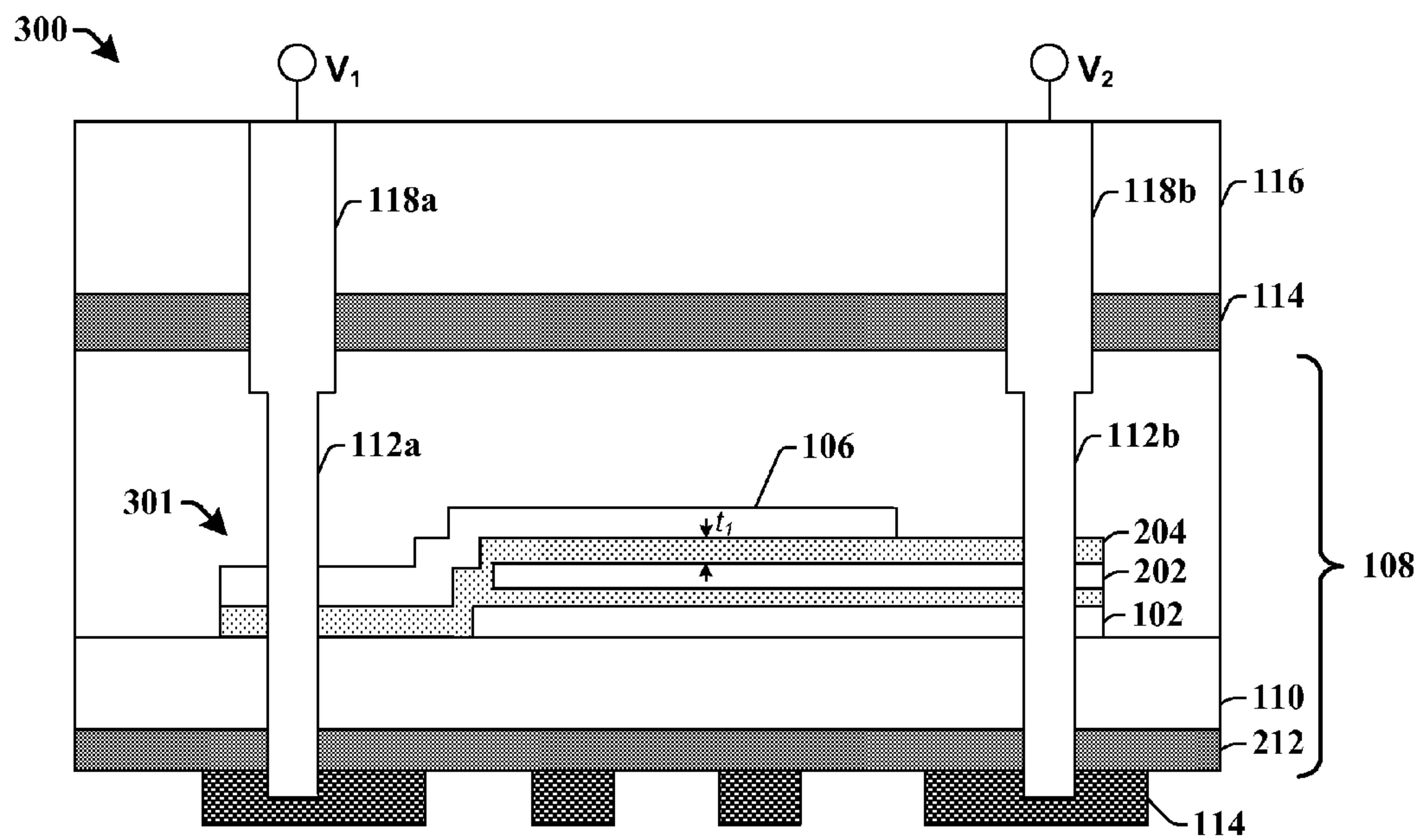


Fig. 3

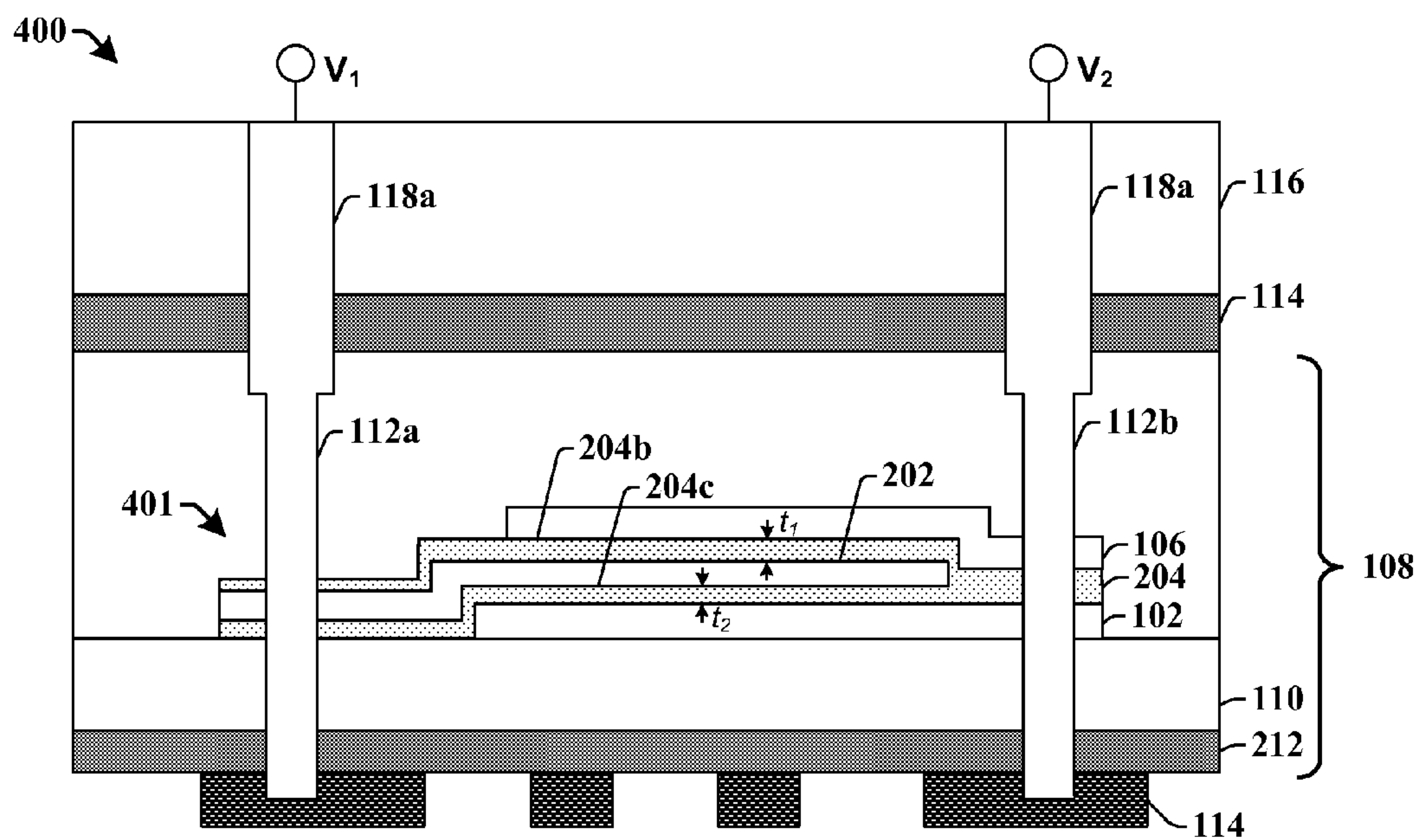


Fig. 4

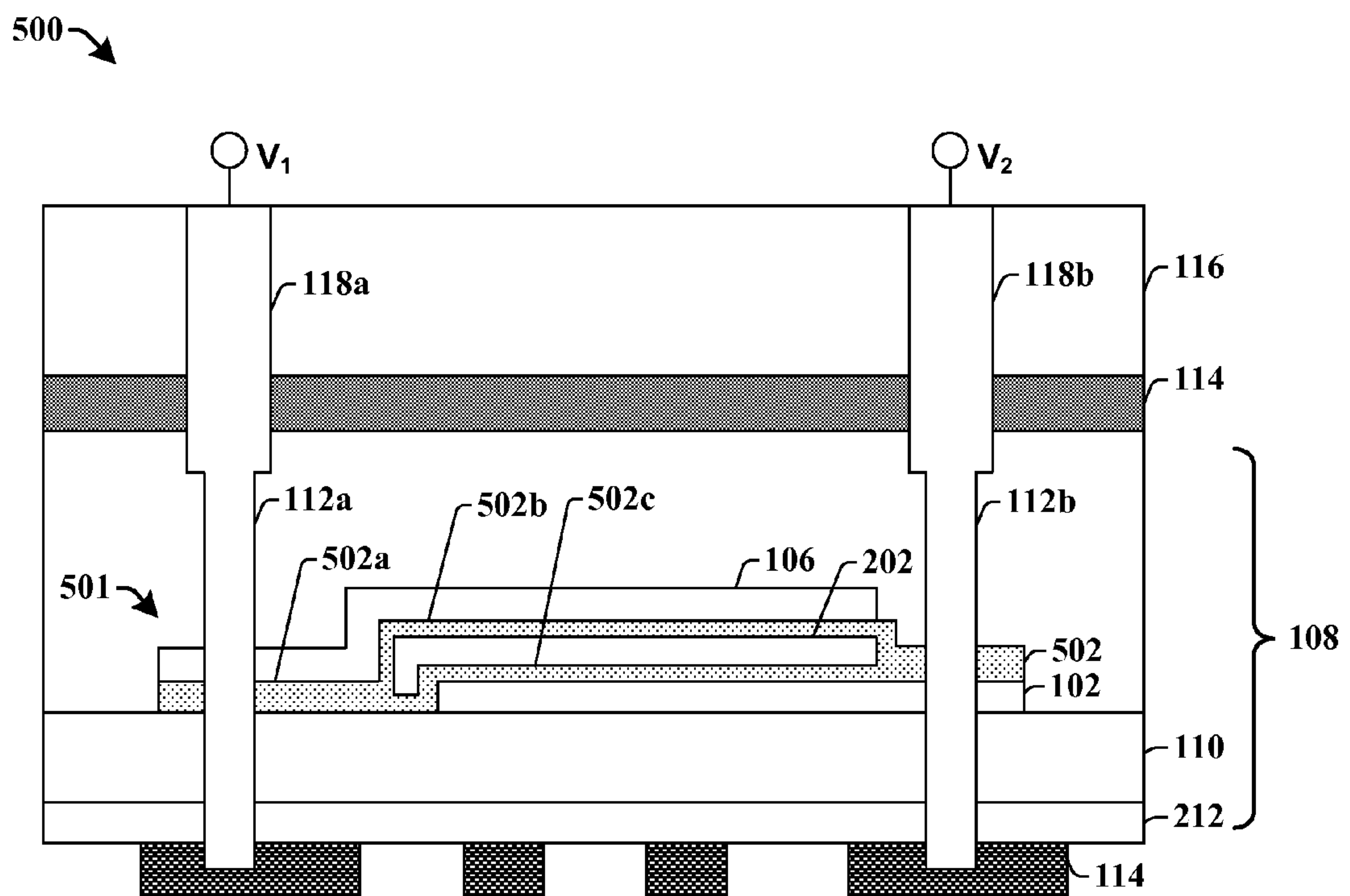


Fig. 5

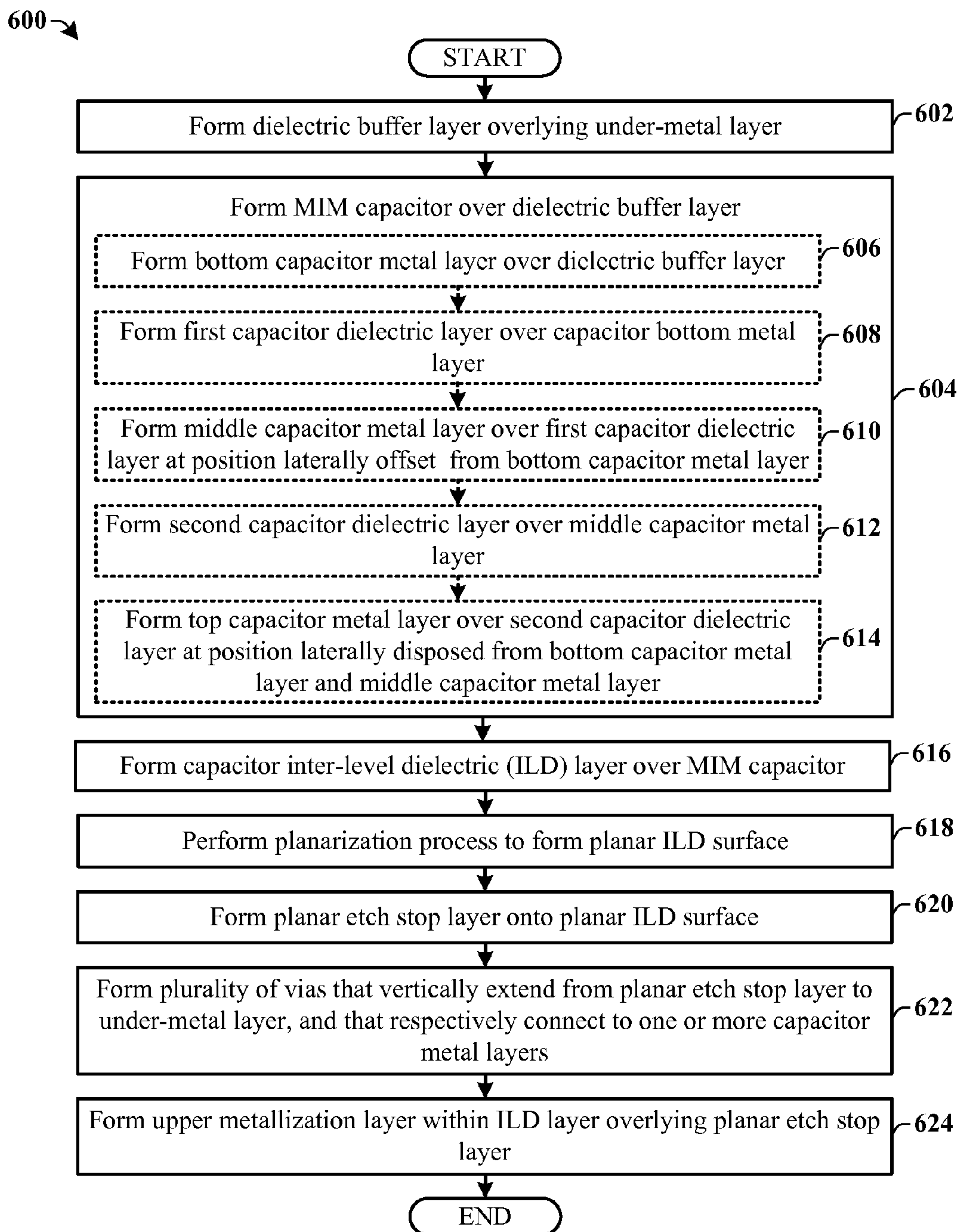


Fig. 6

MIM CAPACITOR STRUCTURE

BACKGROUND

Integrated chips are formed on semiconductor die comprising millions or billions of transistor devices. The transistor devices are configured to act as switches and/or to produce power gains so as to enable logical functionality for an integrated chip (e.g., form a processor configured to perform logic functions). Integrated chips often also comprise passive devices, such as capacitors, resistors, inductors, varactors, etc. Passive devices are widely used to control integrated chip characteristics (e.g., gain, time constants, etc.) and to provide a single integrated chip with a wide range of different functionalities (e.g., manufacturing analog and digital circuitry on the same die).

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. 1 illustrates a cross-sectional view of some embodiments of an integrated chip having a MIM (metal insulator metal) capacitor.

FIG. 2 illustrates a cross-sectional view of some additional embodiments of an integrated chip having a MIM capacitor.

FIG. 3 illustrates a cross-sectional view of some additional embodiments of an integrated chip having a MIM capacitor with an I/O connection.

FIG. 4 illustrates a cross-sectional view of some additional embodiments of an integrated chip having a MIM capacitor with a core connection.

FIG. 5 illustrates a cross-sectional view of some additional embodiments of an integrated chip having a MIM capacitor with a series connection.

FIG. 6 illustrates a flow diagram of some embodiments of a method of forming an integrated chip comprising a MIM capacitor.

DETAILED DESCRIPTION

The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are

intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly.

MIM (metal-insulator-metal) capacitors are a particular type of capacitor, having a top metal plate and a bottom metal plate separated by a capacitor dielectric, which are often implemented in integrated circuits. MIM capacitors can be used as decoupling capacitors configured to mitigate power supply or switching noise caused by changes in current flowing through various parasitic inductances associated with an integrated chip and a package in which the integrated chip is located. For example, simultaneous switching of the input/output (I/O) and core circuits within an integrated chip can cause a voltage drop on a power supply source by an amount proportional to the inductance of a power bus. This power supply noise may increase signal delay, thereby reducing the operating frequency of a system-on-a-chip (SoC), and inadvertently cause state transitions in logic circuits within the SoC.

MIM capacitors are often integrated into back-end-of-the-line (BEOL) metallization stack, at a position that is vertically disposed between an underlying first metal layer and an overlying second metal layer. However, positioning a MIM capacitor within a BEOL metallization stack can present a number of fabrication problems. For example, MIM capacitors typically have a large number of layers that lead to a topography (e.g., having a step size of more than 400 nm) which is greater than most BOEL metallization layers. Furthermore, metal interconnect layers are not permitted since hillocks, or spike like projections, from such ‘under-metal layers’ may cause electrical shorting between the under-metal layers and the MIM capacitor.

The present disclosure relates to an integrated chip having a MIM (metal-insulator-metal) capacitor and an associated method of formation. In some embodiments, the integrated chip comprises a MIM capacitor disposed within a capacitor inter-level dielectric (ILD) layer. An under-metal layer is disposed below the capacitor ILD layer and comprises one or more metal structures located under the MIM capacitor. A plurality of vias are configured to vertically extend through the capacitor ILD layer and the MIM capacitor. The plurality of vias are configured to provide for an electrical connection to the MIM capacitor and to the under-metal layer. By using the plurality of vias to provide for vertical connections to the MIM capacitor and to the under-metal layer, the integrated chip does not use vias that are specifically designated for the MIM capacitor, thereby decreasing the complexity of the integrated chip fabrication.

FIG. 1 illustrates a cross-sectional view of some embodiments of an integrated chip 100 having a MIM (metal-insulator-metal) capacitor 101.

The MIM capacitor 101 includes a bottom electrode comprising a bottom capacitor metal layer 102 and a top electrode comprising a top capacitor metal layer 106. The bottom and top capacitor metal layers, 102 and 106, are electrically isolated from one another by a capacitor dielectric layer 104. The capacitor dielectric layer 104 is configured to separate the bottom capacitor metal layer 102 (i.e., the bottom electrode) from the overlying top capacitor metal layer 106 (i.e., the top electrode), so that the MIM capacitor 101 is able to store energy in an electric field generated between the bottom and top electrodes.

The bottom and top capacitor metal layers, 102 and 106, are laterally displaced from one another, such that the bottom

capacitor metal layer **102** extends beyond the top capacitor metal layer **106** in a first direction, while the top capacitor metal layer **106** extends beyond the bottom capacitor metal layer **102** in an opposite, second direction. For example, in MIM capacitor **101**, the top capacitor metal layer **106** extends beyond the bottom capacitor metal layer in region **105a**, while the bottom capacitor metal layer **102** extends beyond the top capacitor metal layer in region **105b**.

The MIM capacitor **101** is disposed within a capacitor inter-level dielectric (ILD) layer **108**. In various embodiments, the capacitor ILD layer **108** may comprise one or more dielectric materials. For example, the capacitor ILD layer **108** may comprise a low-k dielectric material, an oxide material, etc. In some embodiments, the capacitor ILD layer **108** may extend below a bottom surface of the MIM capacitor **101** (below line **109**) as a dielectric buffer layer **110**. In various embodiments, the dielectric buffer layer **110** may have a thickness t_b that is in a range of between approximately 5% and approximately 50% of the thickness of the capacitor ILD layer **108**.

An under-metal layer **114** comprising one or more metal structures is disposed under the MIM capacitor **101** at a position below the dielectric buffer layer **110**. By separating the bottom capacitor metal layer **102** from the under-metal layer **114**, the dielectric buffer layer **110** is configured to prevent hillocks (i.e., hill-like or spike-like projections) from the under-metal layer **114** from electrically shorting to the bottom capacitor metal layer **102** of the MIM capacitor **101**. Furthermore, by isolating the MIM capacitor **101** from under-metal layer **114** the dielectric buffer layer **110** also prevents the MIM capacitor **101** from introducing a parasitic capacitance into the under-metal layer **114**.

The MIM capacitor **101** further comprises a plurality of vias **112**, which are configured to provide for vertical connections perpendicular to the top surface of the capacitor ILD layer **108**. The plurality of vias **112** are configured to vertically extend from a metal interconnect layer **118** within a metal interconnect ILD layer **116** overlying a planar etch stop layer **114**, through the MIM capacitor **101** to the under-metal layer **114**. The plurality of vias **112** provide for an electrical connection to both the MIM capacitor **101** and to the under-metal layer **114**. Because the bottom and top capacitor metal layers, **102** and **106**, are laterally displaced from one another, the plurality of vias **112** are able to provide for connections to one of the bottom or top capacitor metal layers, **102** or **106**, without electrically contacting the other capacitor metal layer.

For example, a first via **112a** is configured to vertically extend through the top capacitor metal layer **106**, and to provide for an electrical connection to the top capacitor metal layer **106** and to the under-metal layer **114**. A second via **112b** is configured to vertically extend through the bottom capacitor metal layer **102**, and to provide for an electrical connection to the bottom capacitor metal layer **102** and to the under-metal layer **114**. By using the plurality of vias **112** to provide for vertical connections to the MIM capacitor **101** and the under-metal layer **114**, the integrated chip **100** does not use vias that are specifically designated for the MIM capacitor, thereby decreasing the complexity of fabrication of the integrated chip **100**.

FIG. 2 illustrates a cross-sectional view of some additional embodiments of an integrated chip **200** having a MIM capacitor **201**.

The MIM capacitor **201** comprises a bottom electrode comprising a bottom capacitor metal layer **102**, a middle electrode comprising a middle capacitor metal layer **202**, and a top electrode comprising a top capacitor metal layer **106**.

The bottom capacitor metal layer **102**, the middle capacitor metal layer **202**, and the top capacitor metal layer **106**, are disposed within a capacitor inter-level dielectric (ILD) layer **108** disposed over a semiconductor substrate (not shown). In some embodiments, the bottom capacitor metal layer **102**, the middle capacitor metal layer **202**, and the top capacitor metal layer **106** may respectively have a thickness in a range of between approximately 100 angstroms and approximately 800 angstroms.

The bottom capacitor metal layer **102**, the middle capacitor metal layer **202**, and the top capacitor metal layer **106**, are separated from one another by a capacitor dielectric layer **204**. The capacitor dielectric layer **204** branches out from a main branch **204a** to an upper branch **204b** and a lower branch **204c**. The middle capacitor metal layer **202** is disposed between the upper branch **204b** and a lower branch **204c**. The branching of the capacitor dielectric layer **204** causes a thickness of the capacitor dielectric layer **204** to vary as a function of position. For example, the main branch **204a** of the dielectric layer has a first thickness t_{d1} , while the upper branch **204b** and a lower branch **204c** have a second thickness t_{d2} less than the first thickness t_{d1} . In some embodiments, the second thickness t_{d2} may have a range of between approximately 20 angstroms and approximately 200 angstroms.

In various embodiments, the bottom capacitor metal layer **102**, the middle capacitor metal layer **202**, and the top capacitor metal layer **106** may comprise various conductive materials, such as indium tin oxide (ITO), aluminum (Al), titanium (Ti), titanium nitride (TiN), tantalum (Ta), tantalum nitride (TaN), tungsten (W), tungsten nitride (WN), molybdenum nitride (MoN), copper (Cu), platinum (Pt), palladium (Pd), osmium (Os), ruthenium (Ru), iridium oxide (IrO₂), rhenium oxide (ReO₂), rhenium trioxide (ReO₃), or a combination thereof.

In some embodiments, the capacitor dielectric layer **204** may comprise a high-k dielectric material (i.e., a dielectric material having a dielectric constant greater than silicon dioxide). In some embodiments, the capacitor dielectric layer **204** may comprise a single layer of dielectric material. For example, in various embodiments, the capacitor dielectric layer **204** may comprise a layer of silicon dioxide (SiO₂), silicon nitride (Si₃N₄), aluminum oxide (Al₂O₃), tantalum oxide (Ta₂O₅), titanium oxide (TiO₂), strontium titanate (SrTiO₃), zirconium oxide (ZrO₂), hafnium oxide (HfO₂), hafnium silicate (HfSiO₄), lanthanum oxide (La₂O₃), yttrium oxide (Y₂O₃), etc. In other embodiments, the capacitor dielectric layer **204** may comprise a complex dielectric layer having two or more layers of different dielectric materials (e.g., a layer of SiO₂ and a layer of Si₃N₄).

A planar etch stop layer **114** is disposed over the capacitor ILD layer **108**. The planar etch stop layer **114** has a planar surface that extends over the MIM capacitor **201**. The planar surface is parallel to a top surface of an underlying semiconductor substrate. A metal ILD layer **116** is disposed over the planar etch stop layer **114**. The metal ILD layer **116** surrounds a metal interconnect layer **118** comprising a conductive material (e.g., copper, aluminum, etc.). A plurality of vias **112** are coupled to the metal interconnect layer **118** and are configured to vertically extend through a planar etch stop layer **114** and the MIM capacitor **201** to the under-metal layer **114**. By connecting the plurality of vias **112** to the MIM capacitor **201** and to the under-metal layer **114** the fabrication of the plurality of vias **112** is simplified. This is because the stacked electrode structure of a MIM capacitor often provides for topography differences between metal layers (e.g., between a capacitor top and bottom metal layers). The topography differences can make it difficult to form vias since more dielec-

5

tric material must be etched to reach the bottom capacitor metal layer than to reach the top capacitor metal layer. By connecting the plurality of vias **112** to the under-metal layer **114**, the plurality of vias **112** are formed to a same depth, thereby avoiding etching differences caused by uneven topography.

It will be appreciated that by providing signals to different capacitor metal layers, the disclosed MIM capacitor can have different capacitive values and therefore can be used for different purposes (e.g., be used for core and I/O connection demands). This is because the different thicknesses of the disclosed capacitor dielectric layer allow for the disclosed MIM capacitor to provide for different capacitive values. For example, a thicker capacitor dielectric layer provides a MIM capacitor with a lower capacitance (and a lower leakage). FIGS. **3-5** illustrate cross-sectional views of some embodiments of an integrated chip having a MIM capacitor configured to provide for different capacitance values.

FIG. **3** illustrates a cross-sectional view of some embodiments of an integrated chip **300** having a MIM capacitor **301** configured to provide for an I/O connection.

MIM capacitor **301** has a first via **112a** connected to a top capacitor metal layer **106** and a second via **112b** connected to a middle capacitor metal layer **202**. The middle capacitor metal layer **202** and the top capacitor metal layer **106** are separated by a capacitor dielectric layer **204** having a first thickness t_1 . Connecting the top capacitor metal layer **106** to a first voltage V_1 (e.g., V_{DD}) and the middle capacitor metal layer **202** to a second voltage V_2 (e.g., V_{SS}) smaller than the first voltage will provide MIM capacitor **301** with a lower capacitance (and a lower leakage) for an I/O connection, which is proportional to a distance between the top capacitor metal layer **106** and the middle capacitor metal layer **202**.

FIG. **4** illustrates a cross-sectional view of some embodiments of an integrated chip **400** having a MIM capacitor **401** configured to provide for a core connection.

MIM capacitor **401** has a first via **112a** connected to a middle capacitor metal layer **202** and a second via **112b** connected to a top capacitor metal layer **106** and a bottom capacitor metal layer **102**. The top capacitor metal layer **106** and the middle capacitor metal layer **202** are separated by a capacitor dielectric layer **204b** having a first thickness t_1 , and the middle capacitor metal layer **202** and the bottom capacitor metal layer **102** are separated by a capacitor dielectric layer **204c** having a second thickness t_2 . Connecting the middle capacitor metal layer **202** to a first voltage V_1 (e.g., V_{DD}) and connecting the top capacitor metal layer and the bottom capacitor metal layer **102** to a second voltage V_2 (e.g., V_{SS}) smaller than the first voltage provides MIM capacitor **301** with a higher capacitance for a core connection than for an I/O connection (e.g., as shown in FIG. **3**). The higher capacitance is contributed to by capacitor dielectric layer **204b** and capacitor dielectric layer **204c**.

FIG. **5** illustrates a cross-sectional view of some embodiments of an integrated chip **500** having a MIM capacitor **501** with a series connection.

MIM capacitor **501** comprises capacitor dielectric layer **502** configured to separate a bottom capacitor metal layer **102** from a middle capacitor metal layer **202** and the middle capacitor metal layer **202** from a top capacitor metal layer **106**. In some embodiments, the capacitor dielectric layer **502** may comprise an opening that contains the middle capacitor metal layer **202**. For example, the capacitor dielectric layer **502** may branch out from a main branch **502a** to an upper branch **502b** and a lower branch **502c**, and then converge back to the main branch **502a**. A middle capacitor metal layer **202** is disposed above the lower branch **502c** of the capacitor

6

dielectric layer **502** along a portion of the bottom capacitor metal layer **102**, so that the capacitor dielectric layer **502** extends beyond both sides of the middle capacitor metal layer **202**.

The top capacitor metal layer **106** is disposed onto the main branch **502a** and the upper branch **502b** of the capacitor dielectric layer **502**. The top capacitor metal layer **106** comprises a stepped metal layer that extends from the main branch **502a** of the capacitor dielectric layer **204** to the upper branch **502b** of the capacitor dielectric layer **502**. By extending from the main branch **502a** to the upper branch **502b**, the top capacitor metal layer **106** is both laterally disposed from the middle capacitor metal layer **202** and vertically disposed above the middle capacitor metal layer **202**.

A first via **112a** and a second via **112a** extend through a planar etch stop layer **114** and the MIM capacitor **501** to an under-metal layer **114**. The first via **112a** connects a first voltage V_1 (e.g., V_{DD}) to the top capacitor metal layer **106** and to the under-metal layer **114**. The second via **112b** connects a second voltage V_2 (e.g., V_{SS}), smaller than the first voltage V_1 , to the bottom capacitor metal layer **102** and to the under-metal layer **114**. By connecting the first via **112a** to the first voltage and the second via **112b** to the second voltage, a series connection is formed for higher voltage applications.

FIG. **6** illustrates a flow diagram of some embodiments of a method **600** of forming an integrated chip comprising a MIM capacitor.

While method **600** is illustrated and described below as a series of acts or events, it will be appreciated that the illustrated ordering of such acts or events are not to be interpreted in a limiting sense. For example, some acts may occur in different orders and/or concurrently with other acts or events apart from those illustrated and/or described herein. In addition, not all illustrated acts may be required to implement one or more aspects or embodiments of the description herein. Further, one or more of the acts depicted herein may be carried out in one or more separate acts and/or phases.

At **602**, a dielectric buffer layer is formed over an underlying under-metal layer. The under-metal layer comprises a metal inter-connect layer within a back-end-of-the-line (BEOL) stack of an integrated chip.

At **604**, a MIM (metal-insulator-metal) capacitor is formed over the dielectric buffer layer. In some embodiments, the MIM capacitor may be formed by formed according to acts **606-614**.

At **606**, a bottom capacitor metal layer is formed over the dielectric buffer layer. In some embodiments, the bottom capacitor metal layer is formed onto and in direct contact with the dielectric buffer layer.

At **608**, a first capacitor dielectric layer is formed over the bottom capacitor metal layer.

At **610**, a middle capacitor metal layer is formed over the first capacitor dielectric layer. The middle capacitor metal layer is formed at a position that is laterally offset from the bottom capacitor metal layer (i.e., at a position that allows for the middle capacitor metal layer to extend beyond the bottom capacitor metal layer).

At **612**, the second capacitor dielectric layer is formed over the middle capacitor metal layer. In some embodiments, the first and second capacitor dielectric layers may comprise different dielectric layers. In other embodiments, the first and second capacitor dielectric layers may comprise a same dielectric layer that extends continuously between the bottom capacitor metal layer, the middle capacitor metal layer, and a top capacitor metal layer (formed at act **614**).

At **614**, a top capacitor metal layer is formed over the second capacitor dielectric layer at a position that is laterally

offset from the bottom capacitor metal layer and the middle capacitor metal layer (i.e., at a position that allows for the top capacitor metal layer to extend beyond the bottom capacitor metal layer and the middle capacitor metal layer).

At **616**, a capacitor inter-level dielectric (ILD) layer comprising an insulating dielectric material is formed over the MIM capacitor.

At **618**, a planarization process is performed to remove a portion of the capacitor ILD layer and to form a planar capacitor ILD surface overlying the MIM capacitor.

At **620**, a planar etch stop layer is formed over the capacitor ILD layer. In some embodiments, the planar etch stop layer is formed by performing a planarization process on the capacitor ILD layer to form a substantially planar surface. The planar etch stop layer is then deposited onto the substantially planar surface to form the planar etch stop layer.

At **622**, a plurality of vias may be formed that vertically extend from the planar etch stop layer to the under-metal layer, and respectively connect to one or more capacitor metal layers. The plurality of vias may be formed performing a selective etching process to form openings vertically extending through the planar etch stop layer, the capacitor ILD layer, the MIM capacitor (e.g., the top capacitor metal layer, the bottom capacitor metal layer, etc.), and the dielectric buffer layer. A metal (e.g., copper, tungsten, aluminum, etc.) is then deposited within the openings to form the plurality of vias.

At **624**, an upper metallization layer is formed within a metal inter-level dielectric (ILD) layer overlying the planar etch stop layer. In some embodiments, the upper metallization layer may comprise a metal wire layer comprising a conductive material configured to provide a lateral connection. In some embodiments, the upper metallization layer may be formed by performing a selective etching process to form trenches within the metal ILD layer and then depositing a metal (e.g., copper, aluminum, etc.) within the trenches in the metal ILD layer.

Therefore, the present disclosure relates to an integrated chip having a MIM (metal-insulator-metal) capacitor and an associated method of formation.

In some embodiments, the present disclosure relates to an integrated chip. The integrated chip comprises a MIM (metal-insulator-metal) capacitor disposed within a capacitor inter-level dielectric (ILD) layer, and an under-metal layer disposed below the capacitor ILD layer and comprising one or more metal structures located under the MIM capacitor. The integrated chip further comprises a plurality of vias configured to extend through the capacitor ILD layer and the MIM capacitor, so that respective vias are configured to provide for an electrical connection to the MIM capacitor and to the under-metal layer.

In other embodiments, the present disclosure relates to a MIM (metal-insulator-metal) capacitor. The MIM capacitor comprises a first electrode comprising a bottom capacitor metal layer disposed onto and in direct contact with a dielectric buffer layer located over an under-metal layer comprising one or more metal structures located under the bottom capacitor metal layer. The MIM capacitor further comprises a capacitor dielectric layer disposed over the bottom capacitor metal layer, and a second electrode comprising a top capacitor metal layer disposed over the bottom capacitor metal layer at a position that causes the top capacitor metal layer to be laterally displaced from the bottom capacitor metal layer. The MIM capacitor further comprises a plurality of vias configured to extend through the bottom capacitor metal layer or the top capacitor metal layer to the under-metal layer, so that respective vias are configured to provide for an electrical

connection to the bottom capacitor metal layer or the top capacitor metal layer and to the under-metal layer.

In yet other embodiments, the present disclosure relates to a method of forming a capacitor. The method comprises forming a MIM (metal-insulator-metal) capacitor disposed within capacitor inter-level dielectric (ILD) layer. The method further comprises forming an under-metal layer disposed below the capacitor ILD layer and comprising one or more metal structures located under the MIM capacitor. The method further comprises forming a plurality of vias configured to extend through the ILD dielectric layer and the MIM capacitor, so that respective vias are configured to provide for an electrical connection to the MIM capacitor and to the under-metal layer.

The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. An integrated chip, comprising:

a MIM (metal-insulator-metal) capacitor disposed within a capacitor inter-level dielectric (ILD) layer and having a first electrode comprising a bottom capacitor metal layer vertically separated by a capacitor dielectric layer from a second electrode comprising a top capacitor metal layer, wherein an outer sidewall of the first electrode is laterally aligned with a first outer sidewall of the capacitor dielectric layer and an outer sidewall of the second electrode is laterally aligned with a second outer sidewall of the capacitor dielectric layer opposing the first outer sidewall;

an under-metal layer disposed below the capacitor ILD layer and comprising one or more metal structures located under the MIM capacitor; and

a plurality of vias vertically extending through the capacitor ILD layer and the MIM capacitor to the under-metal layer.

2. The integrated chip of claim 1, wherein the capacitor ILD layer extends below the MIM capacitor to form a dielectric buffer layer that separates the MIM capacitor from the under-metal layer.

3. The integrated chip of claim 2, wherein the second electrode is disposed over the bottom capacitor metal layer at a position that causes the top capacitor metal layer to be laterally displaced from the bottom capacitor metal layer.

4. The integrated chip of claim 3, wherein the plurality of vias comprise:

a first via vertically extending through the bottom capacitor metal layer at a first position laterally disposed from the top capacitor metal layer; and

a second via vertically extending through the top capacitor metal layer at a second position laterally disposed from the bottom capacitor metal layer.

5. The integrated chip of claim 2, wherein the bottom capacitor metal layer is disposed onto and in direct contact with the dielectric buffer layer.

6. The integrated chip of claim 1, wherein the MIM capacitor further comprises:

9

a third electrode comprising a middle capacitor metal layer, arranged between and separated from the top capacitor metal layer and the bottom capacitor metal layer by the capacitor dielectric layer.

7. The integrated chip of claim 6, wherein the capacitor dielectric layer has a first thickness at a first position between the bottom capacitor metal layer and the top capacitor metal layer and a second thickness at a second position between the bottom capacitor metal layer and the middle capacitor metal layer.

8. The integrated chip of claim 7, wherein the capacitor dielectric layer branches out from a main branch abutting a dielectric buffer layer that separates the MIM capacitor from the under-metal layer to a lower branch and an upper branch; and

wherein the lower branch is disposed between the bottom capacitor metal layer and the middle capacitor metal layer, and wherein the upper branch is disposed between the middle capacitor metal layer and the top capacitor metal layer.

9. The integrated chip of claim 6, wherein the bottom capacitor metal layer, the middle capacitor metal layer, and the top capacitor metal layer respectively have a thickness that is between approximately 100 angstrom and approximately 800 angstrom.

10. The integrated chip of claim 6, wherein the third electrode is separated from a first via contacting the first electrode and is further separated from a second via contacting the second electrode, and wherein the first via and the second via are different vias.

11. The integrated chip of claim 6, wherein the plurality of vias comprise a first via coupled to the first electrode and the third electrode, and a second via coupled to the second electrode.

12. The integrated chip of claim 6, wherein the third electrode is not in contact with an underlying or an overlying via.

13. The integrated chip of claim 1, further comprising: a substantially planar second etch stop layer disposed over the capacitor ILD layer.

14. A MIM (metal-insulator-metal) capacitor, comprising: a first electrode comprising a bottom capacitor metal layer disposed onto and in direct contact with a dielectric buffer layer located over an under-metal layer comprising one or more metal structures located under the bottom capacitor metal layer;

a capacitor dielectric layer disposed over the bottom capacitor metal layer;

a second electrode comprising a top capacitor metal layer disposed over the bottom capacitor metal layer at a position that causes the top capacitor metal layer to be laterally displaced from the bottom capacitor metal layer;

a third electrode having an 'L' shape and comprising a middle capacitor metal layer, vertically separated from the top capacitor metal layer and the bottom capacitor metal layer by the capacitor dielectric layer and laterally separated from a first via contacting the first electrode and a second via contacting the second electrode, wherein the first via and the second via are different vias wherein the third electrode comprises opposing outermost sidewalls that are between the first and second vias; and

10

wherein the first via and the second via vertically extend through the bottom capacitor metal layer or the top capacitor metal layer to the under-metal layer.

15. The MIM capacitor of claim 14, wherein a thickness of the capacitor dielectric layer varies from a first thickness at a first position between the bottom capacitor metal layer and the top capacitor metal layer, and a second thickness at a second position between the bottom capacitor metal layer and the middle capacitor metal layer.

16. The MIM capacitor of claim 14, wherein the capacitor dielectric layer branches out from a main branch abutting the dielectric buffer layer to a lower branch and an upper branch, wherein the lower branch is disposed between the bottom capacitor metal layer and the middle capacitor metal layer, and wherein the upper branch is disposed between the middle capacitor metal layer and the top capacitor metal layer.

17. The MIM capacitor of claim 14, further comprising: a capacitor inter-level dielectric (ILD) layer disposed over the top capacitor metal layer; and a substantially planar second etch stop layer disposed over the capacitor ILD layer.

18. A method of forming an integrated chip having a MIM (metal-insulator-metal) capacitor, comprising:

forming a MIM (metal-insulator-metal) capacitor disposed within capacitor inter-level dielectric (ILD) layer and comprising a first electrode vertically separated from a second electrode by a capacitor dielectric layer, wherein an outer sidewall of the first electrode is laterally aligned with a first outer sidewall of the capacitor dielectric layer and an outer sidewall of the second electrode is laterally aligned with a second outer sidewall of the capacitor dielectric layer opposing the first outer sidewall;

forming an under-metal layer disposed below the capacitor ILD layer and comprising one or more metal structures located under the MIM capacitor; and

forming a plurality of vias vertically extending through the capacitor ILD layer and the MIM capacitor to the under-metal layer.

19. The method of claim 18, wherein forming the MIM capacitor, comprises:

forming a bottom capacitor metal layer;

forming a first capacitor dielectric layer onto the bottom capacitor metal layer;

forming a middle capacitor metal layer over the first capacitor dielectric layer at a position that is laterally offset from the bottom capacitor metal layer;

forming a second capacitor dielectric layer onto the middle capacitor metal layer; and

forming a top capacitor metal layer over the second capacitor dielectric layer at a position that is laterally offset from the bottom capacitor metal layer and the middle capacitor metal layer.

20. The method of claim 18, further comprising:

performing a planarization process on the capacitor ILD layer to form a substantially planar surface; and

forming a substantially planar second etch stop layer disposed over the capacitor ILD layer.

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